

CLAIMS

Having thus described our invention, what we claim as new and desire to secure by the Letters Patent is:

- 1 1. A ferroelectric capacitor comprising a conductive
2 electrode layer; a ferroelectric layer disposed on said
3 conductive electrode layer; a conductive counterelectrode
4 layer formed on said ferroelectric layer and an at least
5 partially decomposed oxygen source layer in proximity to
6 one of said electrode layers.
- 1 2. The ferroelectric capacitor of Claim 1 wherein said
2 conductive electrode layer and said conductive
3 counterelectrode layer are composed of the same or
4 different conductive material selected from the group
5 consisting of noble metals, noble metal oxides, conductive
6 oxides and mixtures and multilayers thereof.
- 1 3. The ferroelectric capacitor of Claim 1 wherein said
2 ferroelectric layer is a perovskite-type oxide, a compound
3 containing a pyrochlore structure, a potassium dihydrogen
4 phosphate, phosphates of rubidium, cesium or arsenic and
5 mixtures or multilayers thereof.
- 1 4. The ferroelectric capacitor of Claim 3 wherein said
2 perovskite-type oxide has the formula ABO_3 , wherein B is at
3 least one acidic oxide containing a metal from Group IVB,

4 VB, VIB, VIIB, IIIA or IB of the Periodic Table of
5 Elements, and A is an additional cation having a positive
6 formal charge of from about 1 to about 3.

1 5. The ferroelectric capacitor of Claim 4 wherein said
2 perovskite-type oxide is a titanate-based ferroelectric, a
3 manganate-based material, a cuprate-based material, a
4 tungsten-bronze niobate, tantalate or titanate, or a
5 bismuth layered-tantalate, niobate or titanate.

1 6. The ferroelectric capacitor of Claim 5 wherein said
2 perovskite-type oxide is strontium bismuth tantalate,
3 strontium bismuth niobate, bismuth titanate, strontium
4 bismuth tantalate niobate, lead zirconate titanate, lead
5 lanthanum zirconate and compositions thereof modified by a
6 dopant material.

1 7. The ferroelectric capacitor of Claim 1 wherein said
2 oxygen source layer is a metal oxide having the formula MO_x
3 wherein M is a noble metal, a non-noble metal or mixtures
4 and alloys thereof and x is from about 0.03 to about 3.

1 8. The ferroelectric capacitor of Claim 1 further
2 comprising additional conductive layers proximate to said
3 electrode, counterelectrode, or oxygen source layer,
4 wherein said additional conductive layer is a material
5 selected from the group consisting of noble metals, noble
6 metal oxides, conductive oxides, metal nitrides, metal

7 silicon nitrides, metal oxides, metal oxynitrides and
8 mixtures or multilayers thereof.

1 9. The ferroelectric capacitor of Claim 1 further
2 comprising one or more dielectric layers formed on the
3 uppermost layer of the capacitor.

1 10. The ferroelectric capacitor of Claim 1 wherein said
2 conductive electrode layers are patterned or non-patterned.

1 11. The ferroelectric capacitor of Claim 1 wherein said
2 oxygen source layer is patterned or non-patterned.

1 12. The ferroelectric capacitor of Claim 1 wherein said at
2 least partially decomposed oxygen source layer and said
3 electrode layer are patterned, said patterned oxygen source
4 layer is under patterned electrode layer, and said
5 ferroelectric layer is disposed so as to contact both top
6 and side surfaces of said patterned electrode layer, and
7 side surfaces of said patterned oxygen source layer.

1 13. The ferroelectric capacitor of Claim 1 wherein said
2 structure is planar or non-planar.

1 14. The ferroelectric capacitor of Claim 1 wherein said
2 ferroelectric layer is replaced by a layer of high-epsilon
3 material having a dielectric constant of 20 or above.

1 15. An integrated ferroelectric/CMOS structure comprising:
2
3 a CMOS structure having at least one transistor;
4
5 a ferroelectric capacitor formed on said CMOS structure,
6 said ferroelectric capacitor comprising a conductive
7 electrode layer, a ferroelectric layer disposed on said
8 conductive electrode layer, a conductive counterelectrode
9 layer formed on said ferroelectric layer and an at least
10 partially decomposed oxygen source layer in proximity to
11 one of said electrode layers; and
12
13 at least one wiring level formed on said ferroelectric
14 capacitor.

1 16. The integrated ferroelectric/CMOS structure of Claim
2 15 wherein said CMOS structure further includes at least
3 one wiring level formed over a semiconductor substrate.

1 17. The integrated ferroelectric/CMOS structure of Claim
2 16 wherein said semiconductor substrate is a semiconducting
3 material selected from the group consisting of Si, Ge,
4 SiGe, GaAs, InAs, InP, other III/V compounds and organic
5 semiconductors.

1 18. The integrated ferroelectric/CMOS structure of Claim
2 15 wherein said conductive electrode layer and said
3 conductive counterelectrode layer are composed of the same

4 or different conductive material selected from the group
5 consisting of noble metals, noble metal oxides, conductive
6 oxides and mixtures and multilayers thereof.

1 19. The integrated ferroelectric/CMOS structure of Claim
2 15 wherein said ferroelectric material is a perovskite-type
3 oxide, a compound containing a pyrochlore structure, a
4 potassium dihydrogen phosphate, phosphates of rubidium,
5 cesium or arsenic and mixtures or multilayers thereof.

1 20. The integrated ferroelectric/CMOS structure of Claim
2 19 wherein said perovskite-type oxide has the formula ABO_3 ,
3 wherein B is at least one acidic oxide containing a metal
4 from Group IVB, VB, VIB, VIIB, IIIA or IB of the Periodic
5 Table of Elements, and A is an additional cation having a
6 positive formal charge of from about 1 to about 3.

1 21. The integrated ferroelectric/CMOS structure of Claim
2 20 wherein said perovskite-type oxide is a titanate-based
3 ferroelectric, a manganate-based material, a cuprate-based
4 material, a tungsten-bronze niobate, tantalate or titanate,
5 or a bismuth layered-tantalate, niobate or titanate.
6

1 22. The integrated ferroelectric/CMOS structure of Claim
2 21 wherein said perovskite-type oxide is strontium bismuth
3 tantalate, strontium bismuth niobate, bismuth titanate,
4 strontium bismuth tantalate niobate, lead zirconate

5 titanate, lead lanthanum zirconate and compositions thereof
6 modified by a dopant material.

1 23. The integrated ferroelectric/CMOS structure of Claim
2 15 wherein said oxygen source layer is a metal oxide having
3 the formula MO_x wherein M is a noble metal, a non-noble
4 metal or mixtures and alloys thereof and x is from about
5 0.03 to about 3.

1 24. The integrated ferroelectric/CMOS structure of Claim
2 15 further comprising additional conductive layers
3 proximate to said electrode, counterelectrode, or oxygen
4 source layer, wherein said additional conductive layer is a
5 material selected from the group consisting of noble
6 metals, noble metal oxides, conductive oxides, metal
7 nitrides, metal silicon nitrides, metal oxides, metal
8 oxynitrides and mixtures or multilayers thereof.

1 25. The integrated ferroelectric/CMOS structure of Claim 15
2 wherein said conductive electrodes are patterned or non-
3 patterned.

1 26. The integrated ferroelectric/CMOS structure of Claim
2 15 wherein said oxygen source layer is patterned or non-
3 patterned.

1 27. The integrated ferroelectric/CMOS structure of Claim
2 15 wherein said at least partially decomposed oxygen source
3 layer and said electrode layer are patterned, said
4 patterned oxygen source layer is under patterned electrode
5 layer, and said ferroelectric layer is disposed so as to
6 contact both top and side surfaces of said patterned
7 electrode layer, and side surfaces of said patterned oxygen
8 source layer.

1 28. The integrated ferroelectric/CMOS structure of Claim
2 15 wherein said wiring levels include at least one
3 conductive layer and at least one dielectric layer.

1 29. The integrated ferroelectric/CMOS structure of Claim
2 15 wherein said ferroelectric capacitor is planar or non-
3 planar.

1 30. The integrated ferroelectric/CMOS structure of Claim
2 15 wherein said ferroelectric layer is replaced with a
3 layer of high-epsilon material having a dielectric constant
4 of 20 or greater.

1 31. A method of fabricating an integrated
2 ferroelectric/CMOS structure comprising the steps of:

3

4 (a) forming at least one complementary metal oxide
5 semiconductor (CMOS) device on a semiconductor wafer;

6

7 (b) forming a ferroelectric capacitor over said CMOS
8 device, said ferroelectric capacitor comprising at least a
9 ferroelectric layer and an oxygen source layer in proximity
10 to a conductive electrode layer, wherein said oxygen source
11 layer is capable of at least partially decomposing at
12 temperatures below 700°C;

1 (c) forming wiring levels on said ferroelectric capacitor
2 at temperatures below 450°C; and
3

4 (d) annealing the structure at a temperature between 300°C
5 and 700°C so as to at least partially decompose the oxygen
6 source layer to release oxygen into the ferroelectric
7 capacitor.

1 32. The method of Claim 31 wherein said CMOS device
2 includes a transistor region and a semiconductor substrate.

1 33. The method of Claim 32 wherein said semiconductor
2 substrate is a semiconducting material selected from the
3 group consisting of Si, Ge, SiGe, GaAs, InAs, InP, other
4 III/V compounds and organic semiconductors.

1 34. The method of Claim 31 wherein said conductive
2 electrode layer and said conductive counterelectrode layer
3 are composed of the same or different conductive material
4 selected from the group consisting of noble metals, noble
5 metal oxides, conductive oxides and mixtures and
6 multilayers thereof.

1 35. The method of Claim 31 wherein said ferroelectric
2 material is a perovskite-type oxide, a compound containing
3 a pyrochlore structure, a potassium dihydrogen phosphate,
4 phosphates of rubidium, cesium or arsenic and mixtures or
5 multilayers thereof.

1 36. The method of Claim 35 wherein said perovskite-type
2 oxide has the formula ABO_3 , wherein B is at least one acidic
3 oxide containing a metal from Group IVB, VB, VIB, VIIB,
4 IIIA or IB of the Periodic Table of Elements, and A is an
5 additional cation having a positive formal charge of from
6 about 1 to about 3.

1 37. The method of Claim 36 wherein said perovskite-type
2 oxide is a titanate-based ferroelectric, a manganate-based
3 material, a cuprate-based material, a tungsten-bronze
4 niobate, tantalate or titanate, or a bismuth layered-
5 tantalate, niobate or titanate.

1 38. The method of Claim 37 wherein said perovskite-type
2 oxide is strontium bismuth tantalate, strontium bismuth
3 niobate, bismuth titanate, strontium bismuth tantalate
4 niobate, lead zirconate titanate, lead lanthanum zirconate
5 and compositions thereof modified by a dopant material.

1 39. The method of Claim 31 wherein said oxygen source
2 layer is a metal oxide having the formula MO_x wherein M is

3 a noble metal, a non-noble metal or mixtures and alloys
4 thereof and x is from about 0.03 to about 3.

1 40. The method of Claim 31 wherein said conductive
2 electrodes are patterned or non-patterned.

1 41. The method of Claim 31 wherein said oxygen source
2 layer is patterned or non-patterned.

1 42. The method of Claim 31 wherein said annealing step is
2 carried out at a temperature of from about 350° to about
3 700°C for a time period of from about
4 1 minute to about 4 hours.

1 43. The method of Claim 42 wherein said annealing step is
2 carried out at a temperature of from about 350° to about
3 500°C for a time period of from about 1 minute to about 10
4 minutes.

1 44. The method of Claim 31 wherein said annealing step is
2 carried out in an inert gas atmosphere that may optionally
3 be mixed with an oxidizing gas.

1 45. The method of Claim 31 wherein said ferroelectric
2 capacitor is planar or non-planar.

1 46. The method of Claim 31 wherein the annealing step is
2 replaced by the step of allowing said oxygen source layer

3 to decompose during steps selected from the group of
4 ferroelectric deposition, top electrode deposition,
5 optional encapsulant deposition, BEOL process and device
6 operation.

1 47. The method of Claim 31 wherein said ferroelectric
2 layer of said ferroelectric capacitor is replaced with a
3 high-epsilon layer having a dielectric constant of 20 or
4 greater.